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(71) Applicant *(for all designated States except US)*: **ZENON ENVIRONMENTAL INC.** [CA/CA]; 3239 Dundas Street West, Oakville, Ontario L6N 4B2 (CA).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **COTE, Pierre** [CA/CA]; 26 Taly-Ho Drive, Dundas, Ontario L9H 3M6 (CA). **HUSAIN, Hidayat** [CA/CA]; 88 Porteous Circle, Brampton, Ontario L6S 5C5 (CA). **BEHMANN, Henry** [CA/CA]; R.R. #1, Puslinch, Ontario N0B 2J0 (CA). **RABIE, Hamid, R.** [CA/CA]; Unit 33, 2665 Thomas Street, Mississauga, Ontario L5M 6G4 (CA). **ADAMS, Nicholas** [CA/CA]; 37 Kipling Road, Hamilton, Ontario L8S 3X2 (CA). **CADERA, Jason** [CA/CA]; 25 Camm Crescent, Guelph, Ontario N1L 1K2 (CA).

(74) Agent: **BERESKIN & PARR**; 40th Floor, 40 King Street West, Toronto, Ontario M5H 3Y2 (CA).

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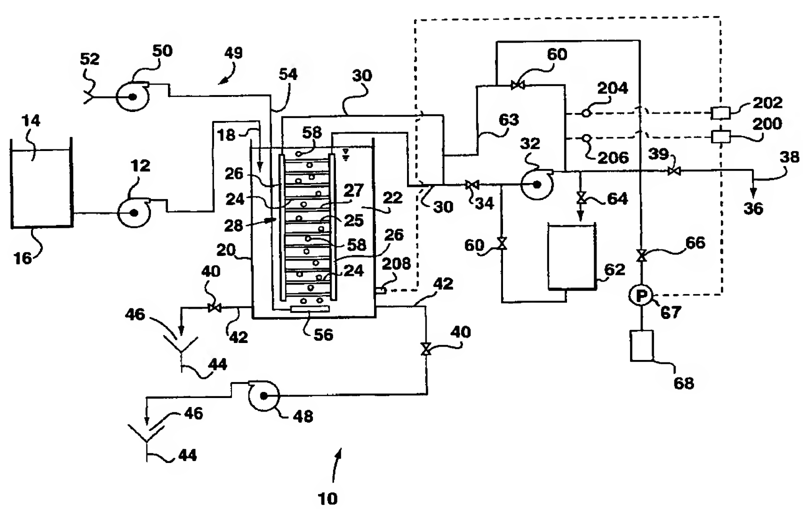
(54) Title: CHEMICAL CLEANING BACKWASH FOR IMMERSED FILTERING MEMBRANES



(57) Abstract: A method of chemically cleaning normally immersed suction driven filtering membranes (24) involves backwashing a chemical cleaner through the membranes while the tank is empty in repeated pulses in which the chemical cleaner is pumped to the membranes (24) separated by waiting periods in which chemical cleaner is not pumped to the membranes (24). The duration and frequency of the pulses is preferably chosen to provide an appropriate contact time of the chemical, preferably without allowing the membranes (24) to dry between pulses and without using excessive amounts of chemical. In other aspects, such membranes (24) preferably used for filtering water to produce potable water in a batch process are backwashed with a chemical cleaner substantially at the same time as the tank is being drained. The chemical cleaner is optionally supplied in pulses.

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Title: Chemical Cleaning Backwash for Immersed Filtering Membranes

FIELD OF THE INVENTION

This invention relates to cleaning normally immersed suction driven ultrafiltration and microfiltration membranes with a cleaning chemical and particularly by backwashing with a chemical cleaner.

BACKGROUND OF THE INVENTION

Normally immersed suction driven filtering membranes are used for separating a permeate lean in solids from tank water rich in solids. Typically, filtered permeate passes through the walls of the membranes under the influence of a transmembrane pressure differential between a retentate side of the membranes and a permeate side of the membranes. Solids in the tank water are rejected by the membranes and remain on the retentate side of the membranes. Over time, however, the solids foul the membranes which decreases their permeability.

The solids may be present in the tank water in solution, in suspension or as precipitates and may further include a variety of substances, some not actually solid, including colloids, microorganisms, exopolymeric substances excreted by microorganisms, suspended solids, and poorly dissolved organic or inorganic compounds such as salts, emulsions, proteins, humic acids, and others. All of these solids can contribute to fouling but the fouling may occur in different ways. Fouling can also occur at the membrane surface or inside of the pores of the membrane. Physical cleaning methods such as aerating the membranes with scouring bubbles and backwashing with permeate counter some forms of fouling. These physical cleaning methods are not very effective, however, for removing solids deposited inside the membrane pores and are almost ineffective for

removing any type of solid chemically or biologically attached to the membranes.

U.S. Patent No. 5,403,479 and Japanese Patent Application No. 2-248,836 describe methods in which chemical cleaning is performed on significantly fouled membranes used to filter wastewater. Permeation is stopped and the membranes are cleaned by continuously flowing a specified amount of chemical cleaner in a reverse direction through the membranes for an extended period of time while the membranes remain immersed in the wastewater and are simultaneously agitated.

French Patent No. 2,741,280 describes a method of backwashing significantly fouled membranes with a chemical cleaner continuously for at least 30 minutes. The tank water is empty during the chemical backwash. When the chemical backwash is over, the cleaner is drained from the tank and the tank is refilled.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of chemically cleaning normally immersed suction driven filtering membranes. This object is met by the combination of features, steps or both found in the independent claims, the dependent claims disclosing further advantageous embodiments of the invention. The following summary may not describe all necessary features of the invention which may reside in a sub-combination of the following features or in a combination with features described in other parts of this document.

In some aspects, the invention is directed at a method of chemically cleaning normally immersed suction driven filtering membranes. A chemical cleaner is backwashed through the membranes while the tank is empty in repeated pulses in which the chemical cleaner is

delivered to the membranes separated by waiting periods in which chemical cleaner is not delivered to the membranes. The duration and frequency of the pulses is chosen to provide an appropriate contact time of the chemical cleaner, preferably without allowing the membranes to dry between pulses and without using excessive amounts of chemical cleaner. When the membranes are vertically oriented hollow fibre membranes, the chemical cleaner is preferably delivered from a header at the top of the membranes only. Preferably, the chemical cleaner has a selected concentration and is provided in each cleaning event for a selected duration. The sum of the products of the concentration and the duration for all of the cleaning events performed in a week is selected to maintain an acceptable permeability of the membranes or to reduce the rate of decline in permeability of the membranes over extended periods of time.

In other aspects, the invention is directed at a process for chemically cleaning such membranes preferably used for filtering water to produce potable water in a batch process. The process involves performing chemical cleaning events from time to time. During the chemical cleaning events, the membranes are backwashed with a chemical cleaner substantially at the same time as the tank is being drained. The cleaning events are performed at least once a day. Preferably, the chemical cleaner has a selected concentration and is provided in each cleaning event for a selected duration. The sum of the products of the concentration and the duration for all of the cleaning events performed in a week is selected to maintain an acceptable permeability of the membranes or to reduce the rate of decline in permeability of the membranes over extended periods of time. The chemical cleaner may optionally be provided in repeated pulses separated by waiting periods.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be

described with reference to the following figure or figures.

Figure 1 is a schematic representation of a filtration system.

Figures 2, 3 and 4 are schematic representations of alternate membrane modules.

Figure 5 is a graph of experimental results.

DETAILED DESCRIPTION OF THE INVENTION

General Description of a Filtration or Permeation Process

Figure 1 shows a reactor 10 for treating a feed water 14 having solids. A feed pump 12 pumps feed water 14 to be treated from a water supply 16 through an inlet 18 to a tank 20 where it becomes tank water 22. In an industrial or municipal reactor 10, the tank 20 is typically between 1m and 10 m deep. During permeation, the tank water 22 is maintained at a level which covers one or more membranes 24. Each membrane 24 has an inner permeate side 25 which does not contact tank water 22 and an outer retentate side 27 which does contact the tank water 22.

Membranes 24 made of hollow fibres are preferred although the membranes 24 may be of various other types such as tubular, ceramic, or flat sheet. The membranes 24 may be assembled into modules 28 in various ways. In a preferred configuration, hollow fibre membranes 24 are held between two opposed headers 26. Potting resin surrounds the retentate sides 27 of the membranes 24 and produces a watertight seal with the headers 26. The permeate sides 25 of the hollow fibre membranes 24 are in fluid communication with at least one conduit in at least one header 26.

Referring to Figure 2, a membrane module 28 may be

made of multiple assemblies of membranes 24 and headers 26 called skeins 8. Figures 3 and 4 show skeins 8 in alternate orientations. Although only a few membranes 24 are illustrated, the skeins 8 are typically between 2 cm and 10 cm wide potted to a packing density between 10% and 40% with hollow fibre membranes 24 having an outside diameter between 0.4 mm and 4.0 mm. The hollow fibre membranes 24 may be between 400 mm and 1,800 mm long and mounted with between 0.1% and 5% slack. The membranes 24 have an average pore size in the microfiltration or ultrafiltration range, preferably between 0.003 microns and 10 microns and more preferably between 0.02 microns and 1 micron.

Referring primarily to Figure 1, to collect permeate the conduit or conduits of headers 26 are connected to a permeate collector 30 and a permeate pump 32 through a permeate valve 34. When permeate pump 32 is turned on and permeate valve 34 and an outlet valve 39 opened, a negative pressure is created on the permeate side 25 of the membranes 24 relative to the tank water 22 surrounding the membranes 24. The resulting transmembrane pressure, typically between 1 kPa and 100 kPa, draws tank water 22 (then referred to as permeate 36) through membranes 24 while the membranes 24 reject solids which remain in the tank water 22. Thus, filtered permeate 36 is produced for use at a permeate outlet 38 through the outlet valve 39. Periodically, a storage tank valve 64 is opened to admit permeate 36 to a storage tank 62.

Tank water 22 which does not flow out of the tank 20 through the permeate outlet 38 flows out of the tank 20 through a drain valve 40 in a retentate outlet 42 to a drain 44 as retentate 46 with the assistance of a retentate pump 48 if necessary. Optionally, tank water 22 which does not flow out of the tank 20 through the permeate outlet 38 may leave the tank 20 by overflowing the tank 20 in addition to or in place of flowing out of the retentate outlet 42. The retentate 46 may be withdrawn from the tank 20 either continuously or periodically.

During permeation, solids accumulate on the surface of the membranes 24 and in their pores, fouling the membranes 24. Physical techniques may prevent some of this fouling. For example, the membranes 24 may be aerated. For this, an aeration system 49 has an air supply pump 50 which blows air, nitrogen or another appropriate gas from an air intake 52 through air distribution pipes 54 to one or more aerators 56 located generally below the membrane modules 28 which disperses air bubbles 58 into the tank water 22. The air bubbles 58 agitate the membranes 24 and create an air-lift effect causing tank water 22 to flow upwards past the membranes 24, all of which inhibits fouling of the membranes 24.

In addition to aeration, the membranes 24 may be backwashed with permeate periodically. For this, permeate valve 34, outlet valve 39 and storage tank valve 64 are closed while backwash valves 60 are opened. Permeate pump 32 is turned on to push filtered permeate 36 from storage tank 62 through a backwash pipe 63 to the headers 26 and through the walls of the membranes 24 in a reverse direction thus pushing away some of the solids attached to the membranes 24. At the end of the backwash, backwash valves 60 are closed. Permeate valve 34 and outlet valve are 39 re-opened if permeation will resume.

Chemical Cleaning

Chemical cleaning events are performed with the tank 20 either empty or emptying, typically through the retentate outlet 42. To clean the membranes 24 with chemical cleaner, permeation is temporarily stopped, permeate valve 34, outlet valve 39 and backwash valves 60 are all closed and permeate pump 32 is turned off. Chemical cleaner is delivered to the membranes 24 and flows through the walls of the membranes 24. The chemical cleaner used may be any chemical appropriate for the application and not overly harmful to the membranes 24. Typical

chemicals include oxidants such as sodium hypochlorite, acids such as citric acid and bases such as sodium hydroxide. The chemical cleaner may be used in a non-liquid form such as by flowing chemical in a gaseous state to the headers 26 or introducing it as a solid into the backwash line 63. Liquid chemical cleaners are preferred, however, because they are easier to handle and inject in the proper amounts.

To flow chemical cleaner through the walls of the membranes 24, chemical valve 66 is opened and chemical pump 67 turned on to flow chemical cleaner from chemical tank 68 to backwash line 63, headers 26 and into or through the walls of the membranes 24. After the chemical cleaning is completed, chemical pump 67 is turned off and chemical valve 66 is closed. Preferably, the backwash valves 60 are opened and permeate pump 32 operated to provide a rinsing backwash to remove chemical cleaner from the backwash line 63 and permeate collectors 30.

Alternatively, backwash valves 60 are opened and permeate pump 32 operated to push filtered permeate 36 from permeate tank 62 through backwash line 63 to the headers 26. Chemical valve 66 is opened and chemical pump 67 turned on mixing chemical cleaner from chemical tank 68 with permeate 36 flowing through backwash line 63. Chemical cleaners could also be introduced directly to the headers 26 or the permeate collector 30 which may reduce the total volume used or allow alternate delivery mechanisms. The membranes 24 can be backwashed with chemical free permeate at the end of a cleaning event to wash chemical cleaner out of the membranes 24 and the tank 20.

In one embodiment, cleaning events are performed with the tank 20 empty. The cleaning events may begin while the tank 20 is being drained but, unlike the embodiment described above, the cleaning events continue for a significant period of time after the tank 20 is drained to below the level of the membranes 24. During the cleaning events, the

membranes 24 are backwashed with a chemical cleaner in repeated pulses in which the chemical cleaner is delivered to the membranes. The pulses are separated by a time in between pulses in which chemical cleaner is not delivered to the membranes.

Preferably, the time between pulses approximates the time required for a dose of chemical to either flow out of the pores of the membranes 24 or to be substantially consumed through reactions with solids such that the membranes 24 are no longer effectively wetted with chemical cleaner. This time may vary with the packing density and configuration of the membrane module 28, the diameter of the membranes 24 and other factors. Providing too short a time between pulses wastes chemical cleaner by forcing it into the tank 20 prematurely while providing too long a time between pulses wastes process time because the chemical cleaner is not sufficiently efficacious for the entire time. Conversely, the duration of the pulse preferably approximates the time required to effectively re-wet the membranes 24 to an initial wetness. In this way, chemical cleaner contacts the membranes 24 for substantially the duration of the cleaning event.

The duration of the pulses is typically between 10 seconds and 120 seconds, more typically between 30 and 60 seconds, and the time in between pulses is typically between 30 seconds and five minutes, more typically about three minutes. Preferably, the first pulse is about 1 to 5 minutes, typically 2 minutes, in duration regardless of the duration of subsequent pulses to fully displace permeate from the permeate sides 25 of the membranes 24 with chemical cleaner such that the next pulse will immediately produce a flow of chemical cleaner through the membranes. Optionally, this first pulse can be performed before the tank is drained or while the tank is draining.

The pressure of the pulses is preferably high enough to

substantially reduce the relative size of differences in local pressure on the permeate side 25 of the parts of the membranes 24 located at different elevations in the tank 20. The pulses preferably have a pressure which exceeds the pressure of a column of water having a height equal to the maximum difference in elevation between two portions of the membranes which typically ranges between 10 and 55 kPa. This produces less variation in the rate of flow of chemical cleaner through different parts of the membranes 24 as compared to when a lower pressure is used and less chemical cleaner is required to achieve a minimum level of cleaning throughout the membranes 24. When vertically oriented hollow fibre membranes 24 are used, the chemical cleaner is preferably delivered to the membranes 24 only through an upper header 26. The head loss in the flow of chemical cleaner through the membranes 24 further assists in counteracting the differences in local pressure inside the lumens of different parts of the membranes 24 caused by differences in elevation in the tank 20. Where such vertically oriented membranes 24 are serviced by upper and lower headers 26 as shown in Figure 3, a lower header cut-off valve 110 is closed so that chemical cleaner flows only into the upper header 26.

The pulsed chemical cleaner delivery is particularly beneficial for modern submerged outside-in hollow fibre membranes 24 which are between 1 metre to 3 metres in length, resulting in significant pressure drop in the lumens of the membranes 24, but having unfouled permeability of a few hundred litres per square meter per hour per bar of transmembrane pressure ($L/m^2/h/bar$) or more. In particular, with chemical cleaner flowing into the upper header 26 only of a membrane module 28 with vertical hollow fibre membranes 24, the head loss in the lumens of the membranes 24 assists in reducing the flow of chemical cleaner through the lower portions of the membranes 24 which, as explained above, tend to receive too much chemical cleaner. With such membranes 24 and chemical cleaner flowing into upper headers 26 only, a

preferred flux of chemical cleaner between 30 and 55 $L/m^2/h$ produces an effective backwash with a pulse pressure near the pressure of a column of water having a height equal to the maximum difference in elevation between two portions of the membranes.

For example, a ZW 500 membrane module manufactured by ZENON Environmental Inc. has vertical hollow fibre membranes approximately 1650 mm in length. In a test with partially fouled fibres having a permeability of 250 $L/m^2/h/bar$ and backwashing from the top header only, backwashing at 7 kPa resulted in a flux of chemical cleaner through the membranes varying from about 17 $L/m^2/h$ at the top of the membranes to about 39 $L/m^2/h$ at the bottom of the membranes. Backwashing at 22 kPa resulted in a flux of about 54 $L/m^2/h$ at the top, about 50 $L/m^2/h$ near the middle and about 61 $L/m^2/h$ near the bottom of the fibres. Thus backwashing at 22 kPa substantially reduced the variation in flux across different parts of the membranes. Continuous backwashing at such a pressure, however, would use excessive amounts of cleaning chemical.

The pressure of the pulses may be controlled by altering the speed of the chemical pump 67 (or the permeate pump 32 and the chemical pump 6 when both are used) with a speed controller 200. Based on the expected permeability of the membranes 24 when fouled, the flux through the membranes at a given pressure can be calculated. From this flux the speed of the chemical pump 67 can also be calculated. The speed controller 200 can thus be set to run the chemical pump 67 at this speed during the parts of the chemical backwash cycle during which the chemical pump 67 is on.

Preferably, the speed controller 200 is controlled by a programmable logic controller 202. The programmable logic controller (PLC) 202 is programmed to turn the chemical pump 67 on and off in

repeated cycles for the duration of the cleaning event. With the on and off times chosen to keep the membranes 24 effectively wetted with chemical cleaner, T entered into the PLC 202 which is programmed to start a timer with the first pulse of chemical cleaner and continue to provide chemical cleaner pulses until T is reached on the timer. More typically, however, T is made to be an even multiple of a selected time between pulses and the PLC is programmed to provide a selected number of pulses.

The PLC 202 starts each on portion of a cleaning event with the chemical pump 67 at the speed calculated above. Optionally, a pressure gauge 204 senses the pressure in the backwash line 63 and converts this information to an analog current or potential signal, preferably a 4–20 mili-amp current signal, proportional to the pressure. The PLC 202 converts this signal to a pressure reading and compares the pressure reading to the desired pressure which is entered into the PLC 202 by an operator. Based on the comparison, the PLC 202 in turn sends an analog current or potential signal, preferably a 4–20 mili-amp current signal, to the speed controller 200. The speed controller 200 changes the frequency of the electric current to the chemical pump 67 in proportion to the signal presented by the PLC 202, which changes the speed of the chemical pump 67, and hence, the chemical cleaner flux and pressure. If the pressure is below the desired value, the speed of the chemical pump 67 is increased by the PLC 202 and conversely decreased if the pressure is too high. In this way, increases in the permeability of the membranes 24 as they are cleaned are compensated for by increasing the speed of the chemical pump 67.

Further optionally, a flow sensor 206 in the backwash line 63 measures the increase in chemical flux caused by such increases in speed of the chemical pump 67 and converts this information to an analog current or potential signal, preferably a 4–20 mili-amp current signal proportional to the flux. The PLC 202 converts this signal to a flux reading. As the chemical flux increases, the time taken to re-wet the membranes 24

decreases. Accordingly, the PLC 202 is programmed to shorten the length of time during which the chemical pump 67 is turned on as the flux of chemical cleaner increases. A level sensor 208 associated with the tank 20 can also be used in conjunction with one or more of the sensors described above and information about the permeability of the membranes 24 to permit the PLC 202 to determine an appropriate speed of the relevant pump to achieve a desired minimum flow of cleaning chemical through membranes 24 at the top of a membrane module 28.

Alternatively, in a large municipal system in which large groups of membrane modules 28 (sometimes called cassettes) are provided each with separately operable valves, the pulsing can be achieved by opening and closing the relevant valves to provide a pulse of cleaning chemical to the various cassettes is sequence. For example, a regimen of 10 second pulses with 50 second waiting periods can be achieved by breaking up the total number of membrane modules 28 into six equal groups, operating the permeate pump 32 or chemical pump 67 to deliver a constant flow of cleaning chemical and opening the relevant valves to each of the six groups of membrane modules 28 in sequence for 10 seconds out of every 60 seconds. This technique reduces wear on the relevant pump cause by its frequent stopping and starting and reduces the extent of a period at the beginning an end of each pulse where the flow of chemical cleaner is increasing or decreasing.

In another embodiment, the chemical cleaning is performed while the tank is being drained. After the drain valves 40 are opened, the permeate pump 32 or chemical pump 67, whichever governs, is controlled to feed the cleaning chemical into the membranes 24, preferably with sufficient pressure to produce a flux of chemical through the membranes 24 between 8.5 $L/m^2/h$ and 51 $L/m^2/h$.

In most industrial or municipal installations it typically

takes between two and ten minutes and more frequently between two and five minutes to drain the tank 20 completely. The time taken to drain the tank 20 can be controlled by operating the retentate valves 40 as required to provide a selected drain time. In combination with a maintenance cleaning regime (to be described below), practical drain times are sufficient to chemically clean the membranes. It is not necessary that the chemical backwash be entirely simultaneous with the tank draining, but it should be substantially so. Once the tank 20 is empty and chemical backwashing is complete, drain valves 40 are closed and a new cycle begins.

By having the chemical backwash coincide with draining the tank 20, a chemical cleaning event that leaves little or no residual chemical cleaner in the tank 20 is performed with minimum loss in permeate production time. In addition, dilution of the cleaning chemical into the tank water occurs only from the portion of membranes 24 or parts of membranes 24 (where the membranes 24 are vertical) covered in tank water, which proportion continually decreases during the backwash. Further, the upper membranes 24 or parts of membranes 24 receive as much chemical as the lower membranes 24 or parts of membranes 24 at least near the beginning of the backwash when the tank water 22 provides a greater head against the lower membranes 24. Thus, the inventors believe that the chemical backwash while draining is at least comparable, if not superior, in contact time generated for a given volume of chemical cleaner to backwashing into either a full or empty tank 20.

In a third embodiment, the two embodiments above are combined to create a pulsed backwash that is performed substantially while the tank 20 is being drained. In this embodiment, the distribution of cleaning chemical is further improved. To accommodate the limited time of the cleaning event, however, the duration of the pulses is preferably between 5 seconds and 30 seconds and the waiting periods preferably last between 30 seconds and 90 seconds.

For all of the embodiments mentioned above, the effectiveness of a chemical cleaning event or backwash may be approximated by multiplying the concentration "C" of the chemical cleaner and the time, "T", that the chemical cleaner effectively wets the membranes 24 to create a third parameter "CT". The preferred CT for each event is selected by an operator according to his or her preferred chemical cleaning regimen, for example a maintenance cleaning regimen as will be described below. Once the CT is selected, a concentration of chemical cleaner is selected. In possible alternative embodiments, the chemical cleaner may be diluted before it reaches the membranes 24. For example, with appropriate modifications to the procedure and apparatus above, backwash valves 60 can also be opened and permeate pump 32 used to flow permeate 36 through backwash line 63 where it mixes with chemical cleaner from the backwash line 63. The concentration of the chemical cleaner is therefore measured as the chemical cleaner meets the permeate side 25 of the membranes 24. A typical chemical cleaner is NaOCl at a concentration between 10 and 200 mg/L. Once C is known, T can be calculated to achieve a desired CT. Since the cleaning events may be repeated with varying frequency for different applications or concentrations of solids in the feed water 14, a parameter called the weekly CT is used as a basis for some calculations. The weekly CT is the sum of the CT parameters for the cleaning events performed during a week.

The embodiments described above are preferably combined with a maintenance cleaning regimen in which the cleaning events are started before the membranes 24 foul significantly. The desired weekly CT is preferably chosen to maintain acceptable permeability of the membranes 24 or to reduce the rate of decline in permeability of membranes 24 over extended periods of time, preferably between 1 month and 6 months, so as to reduce the frequency of intensive recovery cleanings rather than to provide recovery cleaning itself. In some drinking water applications,

however, intensive recovery cleanings can be postponed almost indefinitely. There may be a slight instantaneous increase in permeability of the membranes 24 after a cleaning event, but this permeability gain is typically lost before the next cleaning event and is not significant enough to be considered recovery cleaning.

For drinking water applications, the weekly CT is preferably between 1,000 min*mg/L to 20,000 min*mg/L when NaOCl is the chemical cleaner and more preferably between 1,000 min*mg/L and 10,000 min*mg/L of NaOCl. When other chemical cleaners are used, the concentration of the chemical cleaner is expressed as an equivalent concentration of NaOCl that has similar cleaning efficacy. For example, for citric acid preferred values are approximately 20 times those given for NaOCl and for hydrochloric acid preferred values are approximately 4 times the values given for NaOCl. For applications in which the membranes are used to produce a filtered effluent from a wastewater treatment process, the product of the concentration of the chemical cleaner expressed as an equivalent concentration of NaOCl in cleaning efficacy and the duration of the cleaning events in a week is between 10,000 min*mg/L and 30,000 min*mg/L. Dividing the weekly CT by the number of cleaning events in a week gives the CT of each cleaning event.

For the pulsed chemical backwash into an empty tank, the duration of cleaning events is not limited by the time required to drain the tank. Such cleaning events are repeated at least once a week, preferably between 1 and 4 times a week. Each cleaning event involves between 5 and 30 pulses, preferably between 6 and 10 pulses times, with a total duration between 10 and 100 minutes, preferably about 30 minutes.

Where the chemical backwash is performed substantially while draining the tank, the cleaning events are performed more frequently, preferably at least once a day. Where such cleaning events are

used in conjunction with a batch filtration process in which the tank is emptied periodically at least once a day, the cleaning events may be performed as often as every time the tank is so drained.

Example 1

A small membrane module of horizontal hollow fibre membranes having approximately 28 m^2 of surface area was backwashed with 10-20 ppm chlorine for three minutes every two hours. The chemical backwash was started at the same time as the tank drains were opened but, because of the size of the tank, draining the tank finished before the chemical backwashing finished. The feed water was from a lake and had a pH of 7.5, a temperature of 20 C, turbidity of 10 - 15 ntu and TOC of about 5 - 8 mg/L. The process was run for over 30 days at a 95% recovery rate at two different permeate fluxes - 20 $L/m^2/h$ and 30 $L/m^2/h$. In both cases, acceptable permeability was maintained over extended periods of time. Figure 5 shows the permeability of the membranes over time at each permeate flux.

Example 2

A membrane module of horizontal hollow fibre membranes was backwashed with 25 ppm chlorine for 10 minutes once per day. The chemical backwash was performed substantially while draining the tank except that a first pulse of 2 minutes duration was performed with the tank full. Subsequent pulses (8 per cleaning event) were 15 seconds in duration separated by 45 second periods in which chemical cleaner was not delivered to the membranes. The feed water had a temperature of 25 C, turbidity of 1 - 5 ntu and TOC of about 2 - 5 ppm. The process was run for over 30 days at between 90% an d 95% recovery rate at a permeate fluxes of 30 $L/m^2/h$. Measured permeability (at 20C) was between about 145 and 165 $L/m^2/h/bar$ for over 30 days and indicated a drop in permeability of only

between 5 and 10 $L/m^2/h/bar$ over the duration of the test.

It is to be understood that what has been described are preferred embodiments to the invention. The invention nonetheless is susceptible to certain changes and alternative embodiments fully comprehended by the spirit of the invention as described above, the scope of which is defined in the following claims.

CLAIMS

We claim:

1. A method for cleaning one or more suction driven filtering membranes immersed during permeation in tank water rich in solids in a tank and used to permeate a water lean in solids in cleaning events repeated from time to time, each cleaning event comprising the steps of:

(a) stopping permeation;
(b) draining the tank water from the tank; and,
(c) backwashing the membranes with a chemical cleaner while the tank water is below the level of the membranes in repeated pulses in which the chemical cleaner is delivered to the membranes separated by a time between pulses in which chemical cleaner is not delivered to the membranes;
(d) refilling the tank; and
(e) resuming permeation.

2. The method of claim 1 wherein the membranes are vertically oriented hollow fibre membranes and the chemical cleaner is delivered to the membranes through an upper header only.

3. The method of claim 2 wherein the membranes are between 1 and 3 m in length and the cleaning chemical is delivered in the pulses at a flux between 30 L/m^2/h and 51 L/m^2/h.

4. The method of any of claims 1 through 3 wherein the pulses have a pressure which exceeds the pressure of a column of water having a height equal to the maximum difference in elevation between two

portions of the membranes.

5. The method of any of claims 1 through 4 wherein the time between pulses is insufficient to allow the membranes to dry substantially from an initial wetted state and the duration of the pulses allows the membranes to be re-wetted to the initial state.

6. The method of claim 5 wherein the duration of the pulses is between 10 seconds and 120 seconds and the time in between pulses is between 30 seconds and six minutes.

7. The method of any of claims 1 through 6 wherein the cleaning events are performed at least once a week.

8. A method for chemically cleaning normally immersed suction driven filtering membranes used for filtering water containing solids in a tank comprising performing chemical cleaning events from time to time, the chemical cleaning events including the steps of:

a) backwashing the membranes with a chemical cleaner substantially while draining the tank; and,

b) refilling the tank.

9. The method of claim 8 wherein the chemical cleaning events are performed at least once a day.

10. The method of any of claims 8 or 9 wherein the membranes are backwashed with the chemical cleaner in repeated pulses in which the chemical cleaner is delivered to the membranes separated by a time between pulses in which chemical cleaner is not delivered to the membranes.

11. The method of claim 10 wherein the membranes are

vertically oriented hollow fibre membranes of at least one metre in length and the chemical cleaner is delivered to the membranes through an upper header only at a flux of at least 30 L/m^2/h.

12. The method of any of claims 10 or 11 wherein the pulses have a pressure which exceeds the pressure of a column of water having a height equal to the maximum difference in elevation between two portions of the membranes.

13. The method of any of claims 10 through 12 wherein the time between pulses is insufficient to allow the membranes to dry substantially from an initial wetted state and the duration of the pulses allows the membranes to be re-wetted to the initial state.

14. The method of claim 13 wherein the duration of the pulses is between 5 seconds and 30 seconds and the time in between pulses is between 30 seconds and 90 seconds.

15. The method of any of claims 1 through 14 wherein the chemical cleaner has a selected concentration and is provided in each cleaning event for a selected duration and he sum of the products of the concentration and the duration for all of the cleaning events performed in a week is selected to maintain an acceptable permeability of the membranes or to reduce the rate of decline in permeability of the membranes over extended periods of time.

16. The method of claim 15 wherein the sum of the products of the concentrations and the durations for all of the chemical cleaning events performed in a week is between 1,000 min•mg/l and 10,000 min•mg/l when NaOCl is the cleaning chemical or an equivalent product of concentration and time of another cleaning chemical and the membranes are used to produce potable water.

17. The method of claim 15 wherein

(a) the membranes are used to produce a filtered effluent from a wastewater treatment process; and,

(b) the product of the concentration of the chemical cleaner expressed as an equivalent concentration of NaOCl in cleaning efficacy and the duration of the cleaning events in a week is between 10,000 minutes•mg/L and 30,000 minutes•mg/L.

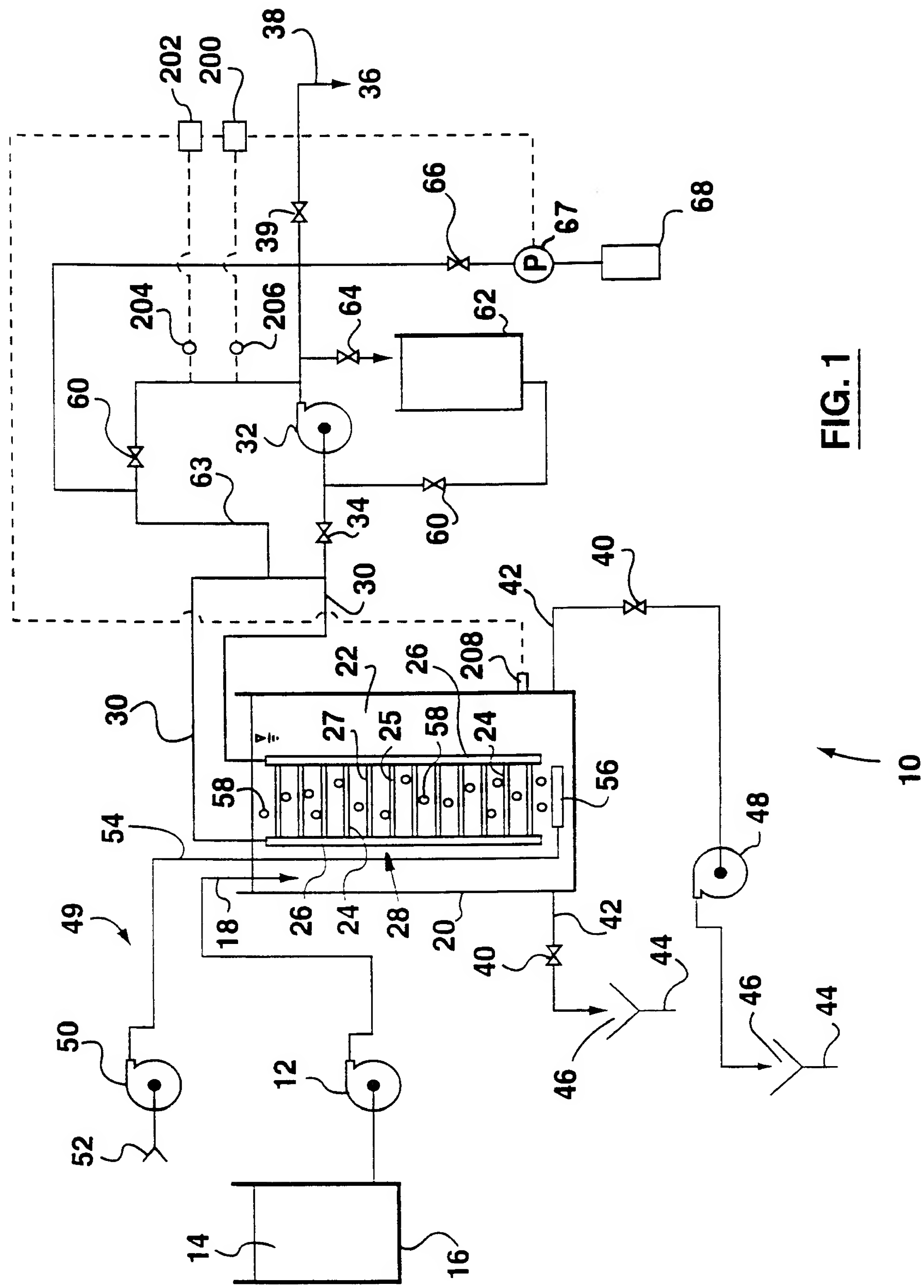

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FIG. 1

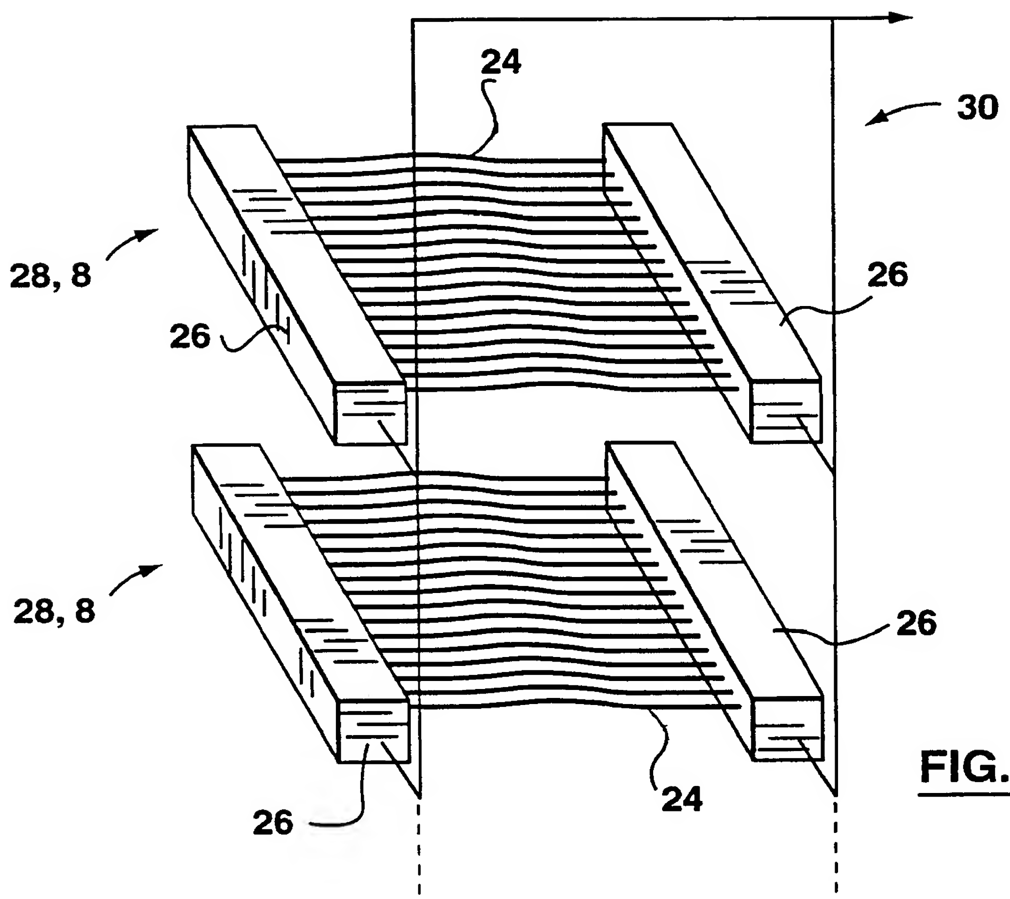
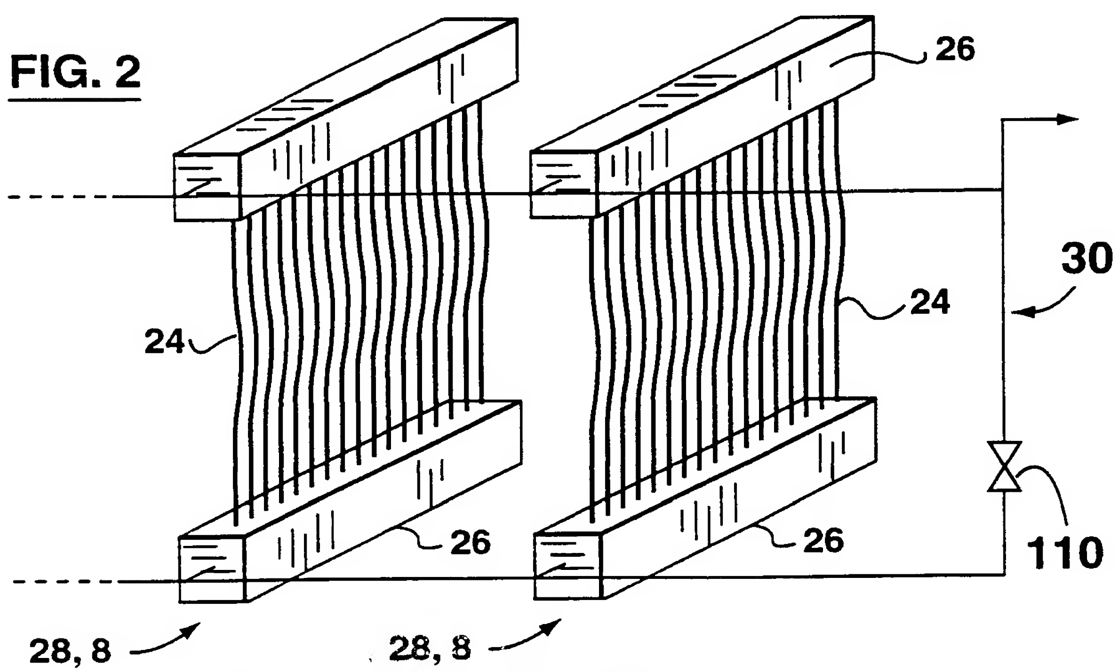


FIG. 3

FIG. 2



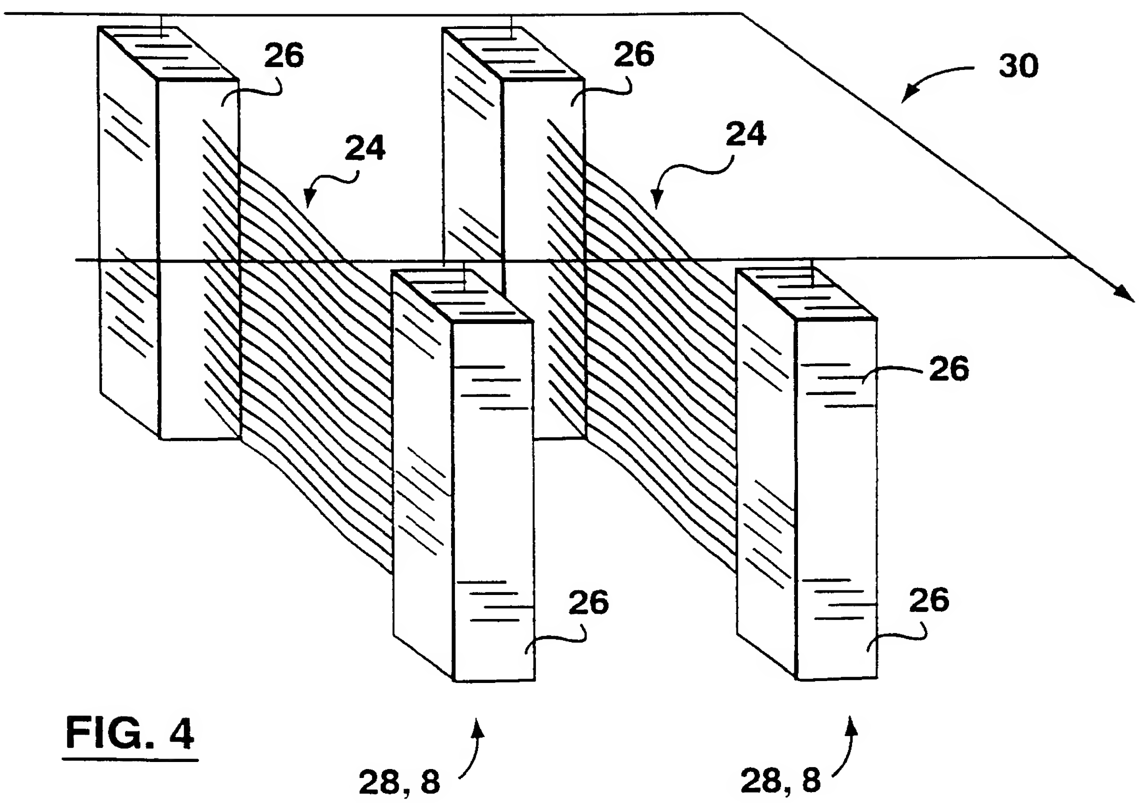
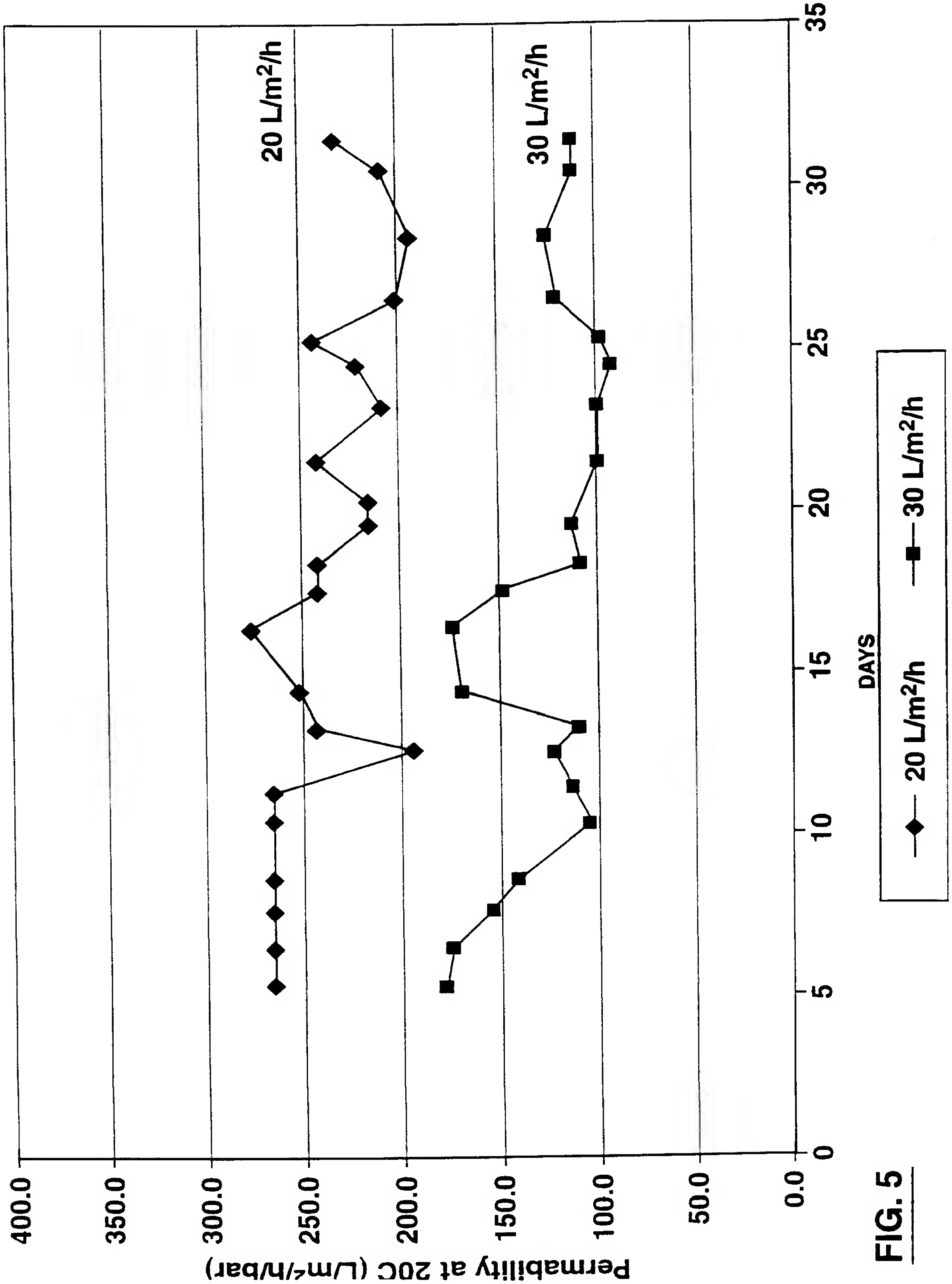


FIG. 4


Permability at 20C (L/m²/h/bar)
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350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
DAYS
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15
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25
30
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20 L/m²/h
30 L/m²/h
20 L/m²/h
30 L/m²/h

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 00/00875

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D65/02 B01D65/06 C02F1/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		2-4,6,7, 9,11,12, 14-17

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 2000	28/11/2000
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Hoornaert, P

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 00/00875

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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